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ABSTRACT

Developments concerning communication satellites and the Australian debate are outlined for the distance educator without a technological background. Social, economic, technical, and policy issues associated with the implementation of an Australian national communication satellite system were assessed in 1977 by a task force whose recommendations are included. An overview of the proposal and reactions of regional television stations, the public, and special groups are included from the text of a 1978 published report. Definitions of telecommunications terms and a summary of technical developments in other countries are also presented. Results of a survey revealed interest by the educational community in a network for continuing education. When economical service becomes available, a network may be developed that provides one-way television and two-way data to each classroom, therefore combining the features of prerecorded lectures, live interaction, and computer-managed instruction. Other applications of the system include: communication links between educational institutions originating educational television and radio programs and between educational institutions and educational centres for distance education purposes. (SW)

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# COMMUNICATION SATELLITES:

# THE AUSTRALIAN DEBATE

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Dean of Educational Services

U.S. DEPARTMENT OF EDUCATION
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## INTRODUCTION

Technology is changing rapidly. The changes are such that educators amongst others need to be alert to the potential inherent in developments, of which communication satellites is but one. For many involved in education, it is not easy to keep abreast of these developments and the present article is intended for distance educators without a technological background (as is the case with the writer) as an aid to following the satellite debate.

## THE TASK FORCE

In November 1977 a Task Force was set up to 'investigate and evaluate the social, economic, technical, policy and other issues associated with the establishment and operation of an Australian National Communication satellite system ... and to 'produce a written report of the Task Forces' findings and recommendations for presentation to the Minister for Post and Telecommunications ...

The report of the Task Force was published in July 1978 and contained the following recommendations.(1)

1. The introduction of an Australian national communications satellite system and that arrangements for its provision to be commenced as early as practicable.

2. That a national satellite commission should be established with the responsibility for assembling user requirements, specifying, planning, providing, developing, marketing and operating the space segment of the national communications satellite system. The new commission should also be responsible for prescribing technical standards and operating procedures for earth stations accessing the space segment. The commission should operate under an Act of Parliament and should report to Parliament through the Minister for Post and Telecommunications.

   The representatives of Telecom Australia and the Department of Finance dissented from Recommendation 2, for reasons outlined in the relevant paragraph.

3. That the new commission should be permitted considerable freedom in the provision and marketing of a full range of satellite communications services with the exceptions of domestic and international telephone, telex and telegram services directly to the public.

4. That should the Government accept the earlier recommendations in this Report it should establish an interim commission.

5. That the earth stations, comprising the earth segment of the national communications satellite system, should be owned by

   . users
   . consortia of users
   . the national satellite commission

   licensed where required, according to the Wireless Telegraphy Act 1905 and operated to standards prescribed by the national satellite commission.

6. That at an appropriate time, the Minister for Post and Telecommunications invite applications for additional television station licences for examination and decision by the Australian Broadcasting Commission Tribunal.

7. That a Direct Broadcasting Service, directed towards the provision of the national television and radio services to isolated communities and homesteads beyond the range of coverage of terrestrial broadcasting services, be considered for inclusion in the national communications satellite system.

8. That special Defence tactical and/or strategic transponders be considered for inclusion in the national communications satellite system.

9. That the national satellite commission, in co-operation with other appropriate organisations, facilitates the conducting of trials.

10. That trials using the existing terrestrial network and/or capacity leased in INTELSAT satellites should be investigated further by, and arranged between, the interested organisations.

11. That the Government allows a period for public consideration of this Report before arriving at its decision regarding a national communication satellite system.

Telecom Submission

One of the submissions to the Task Force was presented by Telecom[2] in which it was noted that a national communications satellite system would have a number of applications as follows.

- High quality telecommunication services to remote areas, some unserviced at the present time, others with poor or marginal quality service.

- Multiple choice TV programme distribution providing much greater flexibility in programming.

- Trunk telephony channels, either augmenting current broadband (coaxial-microwave) routes or providing new routes.

- Specialised services for defence communication requirements to mobile and transportable installations on land and sea.

- Foreign Affairs communications services.

An enhanced telecommunications network which has greater capacity to absorb terrestrial route failures (more 'survivable') and can respond more quickly to sudden changes in need, eg. in emergencies.

Amongst the conclusions the submission noted:

> Any national communication satellite system of the types currently available should form an integral part of the national telecommunications system. Because of the need to carefully design and maintain the interface, and, as many of the probable services as those which it is Telecom's responsibility to provide, the most sensible approach for the management of the total investment in telecommunications would be for the satellite system to be owned and operated by Telecom Australia.

Media Report

The Age of September, 1978, carried the following report[3] which provides something of an overview and indicates some of the reactions of the proposal. The text of the report is reproduced below:

> A Government committee has recommended that Australia should have a domestic satellite communications system as soon as practicable.
>
> But the final go-ahead should depend on potential users of the system - which would cost more than $200 million - indicating their interest, the committee says ...
>
> Cabinet is expected to set up an interdepartmental group to examine the recommendations.
>
> The Government established the inquiry into a domestic satellite system late last year.
>
> This followed a proposal from Mr. Kerry Packer's Consolidated Press group for a programme to launch three satellites to expand and improve nationwide access to television.
>
> The national satellite committee was headed by the general manager of the Overseas Telecommunications Commission, Mr. Harold White.
>
> Telecom was represented on it, as were the Departments of Defence, Transport, Post and Telecommunications, Heatlh and Finance.
>
> But the Finance Department expressed grave reservations in the report about the feasibility of the satellite system - because of its vast cost.
>
> The report says an accurate costing would need further investigation. But it ranges from $123 million to $160 million for the satellites, plus extra costs for an extensive network of ground stations.
>
> The report discusses various options for ownership and control of the system, which would take six years to plan and launch.
>
> It favours government ownership, with the system managed by a few statutory authority.
>
> Commercial organisations would have the right of access on a business basis.
>
> The report says the system could be used for health services, education, transport scientific uses and defence purposes, as well as commercial activities.
>
> It says the three major commercial capital city television networks - Seven, Nine and 0-10 - could be interested in leasing satellite capacity.
>
> With a satellite system, it would be feasible to relay major network programmes to every corner of the country.
>
> This would increase the choice of stations for viewers outside metropolitan areas.

The Prime Minister, Mr. Fraser, has expressed interest in a satellite system, after seeing the Canadian domestic communications system.

The report indicates the high cost of the system in getting television and radio services to people in the very isolated areas.

Reactions

Support for a national satellite system is not unanimous. As the previous press statement indicates the Finance Department is reported to have grave reservations because of the cost of such a system. The Australian Postal and Telecommunications Union produced and distributed a leaflet which labels the proposal 'A cruel fraud', places the cost at 'in excess of 500 million dollars' and concludes that 'The Trade Union Movement should be totally opposed to the intr duction of a Satellite at this time ... The Satellite system must be declared black, public support must be given and this issue must be made the number one priority of issues at this time'.(4)

The attitude of regional T.V. stations is also negative exemplified by a letter to shareholders issued by one such company the text of which reads:(5)

> Your Directors' believe that the Company's Shareholders should be made aware of the possible implications arising from proposals for a Domestic Satellite over Australia, as set out in the recent Government Task Force Report.
>
> Briefly, this calls for a satellite to be launched at enormous cost, which is justified by proposals to extend programs of metroplitan networks to all country areas, including those already served by Independent stations.
>
> Your Company would not argue against the use of satellites for normal communications, or replacing existing TV landlines, but the proposal goes much further in suggesting the establishment of additional TV stations in each area.
>
> To do this, it would be necessary to change the ownership provision of the Broadcasting & Television Act, and your Directors believe such changes would mean that your Company's operations would be serverly hampered and that all local programs and identity would disappear.
>
> In addition, your Company's ability to maintain profitability would be seriously in doubt.
>
> Any influence you may be able to bring to bear upon Federal Parliamentarians in this matter, will be to the benefit of both Shareholders and viewers.

Public Participation in the Debate

Against this backdrop, the Centre for continuing Education at the Australian National University planned a three day conference on the theme 'A Communications Satellite for Australia - Who Will Benefit?' The intention of the organisers of the conference was announced in the following terms:(6)

> The aim of the conference is to demystify satellite technology and to define potential user's requirements.

It will examine the consequences of the Australian Satellite Task Force Inquiry and will focus attention on non-profit public applications of satellite technology.

The conference co-ordinator, Chris Deacon, said that the future users of the satellite system - universities, schools, libraries, hospitals, health centres, state governments, public broadcasters, emergency services and remote communities - should be taking part in the planning stages of the domestic satellite system.

He said that the proposals of the Satellite Task Force offer little for the 'commercially insignificant' users of satellite technology, in spite of the existence elsewhere of low-cost ground station equipment.

'Now is the time to ensure that adequate facilities are made available to public interests, and at a cost they can afford', he said.

The conference will include a wide-ranging series of workshops which will examine the application of satellite technology in such areas as education; data and message services; health and medicine; library and information services; community and social service; commerce; science; broadcasting; and public safety and law enforcement.

The New Language

For those who are not technically minded, discussions about satellite systems can quickly assume a science fiction quality. This need not be so. Certainly the language has to be learned. Several glossaries have been prepared but perhaps the most useful course of action is to quote the glossary provided by the Centre for Continuing Education, ANU.(7)

*Communication Satellite:*
A man-made object carrying electronic equipment capable of receiving and transmitting communications signals to and from earth.

*Synchronous Satellite:*
A satellite positioned 22,300 miles in space where it rotates at the same speed as the earth, thus appearing stationary overhead.

*Fixed Satellite:*
Low to medium power satellite which sends signals to large (30-90 foot dish antennas) and expensive ($100,000 - $5,000,000) earth stations mounted atop home or office buildings.

*Earth Station (Terminal):*
Equipment on earth used for reception and/or transmission of signals to and from a satellite.

*Transponder:*
Device on a satellite which receives signals from earth station, amplifies them, and then retransmits them to earth. Commercial satellites now in use are equipped either with 12 or 24 transponders, each of which can handle one TV signal or about 600 two-way audio signals.

*Footprint:*
The area on earth within which a satellite's signal can be received.

*Launch Vehicle:*
A rocket used to place a satellite in orbit. Soon, satellites will be launched by NASA's space shuttle.

*Payload:*
The equipment placed upon a rocket that is launched into space, ie. a satellite.

*Power Flux Density:*
The amount of power (measured in Watts) available on a satellite to transmit signals to earth. The more power than can be put on a satellite, the smaller and less expensive can be the receiving and transmitting equipment on the ground.

*Frequency:*
The number of complete cycles of current per second produced by an alternating current generator, usually expressed in hertz.

*Bandwidth:*
The capacity of an electronic communications system, measured in frequencies. The radio spectrum assigned to satellites is 500 megahertz wide. The bandwidth required to transmit TV is 4.5 megahertz; stereophonic radio, 15 kilohertz; telephony (including telex, facsimile, data and slow-scan TV), 3 kilohertz.

Satellites Simplified

Arthur C. Clarke in February of 1946 is credited with the beginnings of communication satellite technology when he spoke of using synchronous space stations to relay radio messages throughout the world. It was only a matter of twenty years before his prediction of three satellites in synchonous orbit providing service to most countries began to come true. Sputnik in 1957, gave the necessary impetus and in the following year or so the United States showed that it was capable of putting satellites into orbit. A paper by James Janky provides a simplified but clear description of what communication satellites are and how they work. Sections of the paper are reproduced here.(8)

> In 1960 the U.S. launched 'Echo' a 100 foot diameter balloon whose surface was composed of metallized plastic which reflected radio waves. Echo was big enough and low enough in its orbit to be seen easily with the naked eye. Also in 1960, NASA and Philco-Ford, now know as the Ford Aerospace Communications Corporation, launched the 'Courier' satellite - the first truly active communications satellite. It could receive messages broadcast from earth and had a tape recorded on board for later playback and retransmission to earth. None of these satellites were capable of receiving signals and retransmitting them back to earth in relay time until TELSTAR was launched in 1962; TELSTAR contained communications equipment which serveed as an active repeater, which could receive, amplify, and retransmit messages in real time. We commonly refer to this type of equipment as a transponder. The signals from earth are received by the satellite, their frequency is changed, they are amplified and retransmitted back to earth.

In those early days earth stations were large and complex while satellites were simple and uncomplicated, placed in low orbit and required continuous tracing from the ground. A significant change occured in 1974 when Janky notes that the development of NASA's large and complicated ATS-6 satellite permitted the use of small and unsophisticated earth stations.

The first step in achieving this transfer of the performance burden was to get a satellite into what is called the synchronous orbit - so named because the rotation of the satellite about the earth is exactly synchronized with the earth's own revolution. Moreover, the orbital plane of the satellite lies in the plane of the equator so that to an observer on earth the position of the satellite remains unchanged. (If the orbital plane of the satellite were inclined with respect to the equator, the satellite would spend half its time in the Northern Hemisphere and half in the south Hemisphere, and would appear to bob up and down in the sky). Sychronous satellites have equatorial orbits appear stationary to an observer on earth and are referred to as geostationary satellites.

This development came when Hughes Aircraft built SYNCOM I which achieved a synchronous geostationary orbit when launched by NASA in 1963 and had one transponder capable of handling one TV channel or 50 telephone circuits. Then came INTELSAT, otherwise known as 'Early Bird' to be followed by three further generations of this spacecraft, each more powerful than its predecessor.

To locate a satellite into orbit, it is first placed in the nose cone of a rocket, which splits into two pieces after the second stage of the rocket is fired. The third stage of the rocket is commonly referred to as the apogeekick motor. Before it is fired, the entire third-stage assembly is spun like a top about is axis of symmetry to provide increased stability. The first two stages of the rocket launch the satellite into an intermediate oribt, which is very elliptical and not in the plan of the equator. This is referred to as the transfer orbit and its point of injection is called the perigee. The high point of the orbit is called the apogee, and at this point the apogeekick motor is fired to circularize the new orbit at synchronous altitude.

The launch process is very complicated and what has been said is only the broadest outline.

When all the corrections have been made and the satellite is in the desired position, it is said to be 'on station' and can provide service contingent only on the amount of 'station keeping' necessary to keep it in its desired position.

Janky points out that a number of forces act to move the satellite from its desired geostationary 'parking space'. These include the earth's irregular elliptical cross-section, a condition referred to as the earth's triaxiality. Because of the resultant gravitational anomalies the satellite drifts to what is called a 'point of accumulation', located over the Indian Ocean, unless corrected.

These corrections are made by firing jets which expel hydrazine, a volatile gas which is stored as a liquid on board in small tanks. On spinning satellites, these jets are pulsed on and off so that their direction of thrust coincides with the desired correction angle. These same small thruster jets also are used to control perturbations which tend to move the satellite in a north-south direction. If left unattended, the combined effects of solar pressure and gravitational pull from the moon and the sun could change the attitude of the spacecraft by over one degree in less than an hour. That is, if the satellite were pointing to Kansas City, the beam center could shift from there to the Gulf of Mexico in less than an hour if left unattended.

These are not the only forces acting to vary the space stations' position but this illustrates the problem.

Later versions of 'spinners' have employed the gyrostat principle, in which only a portion of the body of the spacecraft revolves. A significant portion of the body and the antenna remain continuously pointed to the earth. NASA's ATS-6 was the first communication satellite to successfully employ three-axis stabilization, in which the entire spacecraft remains oriented to the earth continuously. Internal momentum wheels (gyroscopes) provide the necessary stability.

So far Janky has touched on three key elements of a satellite - the transponder, the antenna, and the attitude control system. Other important factors are the power supply system (solar-cells), power conditioning equipment and batteries.

Eclipse occurs twice a year, during the spring and fall equinox, when the axis of the earth is perpendicular to its orbital about the sun. At these times, the earth is in a direct line between the satellite and the sun at local midnight. The duration of the eclipse gradually increases over a week's period to a maximum of about 72 minutes and then decreases again. To minimize the amount of battery power required, satellites are general located to the west of the target area on earth, since eclipse will then occur between local midnight and 6.00. All, when service demands are at a minimum.

The temperature of the spacecraft must be regulated to prevent those portions continuously in the sun from becoming too hot and those portions in darkness from becoming too cold. Heat dissipated by the electronic equipment must be radiated to space. The required thermal control is usually accomplished by controlling the emissivity of various surfaces of the spacecraft. Emissivity refers to the ability of a surface to radiate or absorb energy. Black surfaces are good absorbers and radiate well; white surfaces are not and do not.

To command and control the satellite, there is a telemetry link with a ground control centre. As spacecraft have become more and more complex, however, computers have been installed on board to perform many of the required control functions autonomically. The radio commands are generally sent to a frequency which differs from that used for communications services and the telemetry antennas are generally omnidirectional, or nearly so, to maintain command and control regardless of the orientation of the spacecraft. The need for omnidirectional antennas is particularly acute during the launch phrase when the satellite may not be oriented toward the earth.

Janky then discusses the development of body-stabilized, or three-axis satellites beginning with NASA's Applications Technology Satellite No. 6 (ATS-6), marking the change in communications network in which the performance burden is placed on the satellite, rather than the earth station.

Janky comments that the principle advantage of a 3-axis stabilized spacecraft lies in its flexibility in terms of achieving various transponder configurations, its greater payload, and its longer life than spinners.

Among the important parameters for users and designers to consider in satellite technology are the size and shape of the antenna coverage pattern ('footprint'), the number and power of transponders, and the choice of frequencies.

Finally, Janky notes the coming of the space shuttle replacing the present expendable and costly rockets used in launching spacecraft. For those who are interested, a more detailed description accompanied by diagrams is to be found in a background paper by Lester R. Free.(9)

Communications Satellites and Applications in Education

So far not a great deal has been written specifically about communication satellites applications in education. Potter, in an article on emerging markets for the satellite communications industry, includes a section on Continuing Education, in which he says:(10)

> In a survey which was administered in the summer of 1976, 81 percent of PSSC's membership expressed interest in a network for continuing education. More recently, PSSC conducted a survey of the membership to determine composite requirements for a federally subsidized Public Service Communications Technology Satellite (presumably SyncomIV with an appropriate communications payload). In the period between October 17, 1977, and January 10, 1978, forty two public service organizations responded in writing or were interviewed by senior staff. Quantitative information regarding the probable demand for private-line video, voice and data circuits was received from seventeen organizations.
>
> The response was strongly oriented toward one-way video. If service which is comparable to that planned for Syncom IV (which is expected to provide an EIRP in excess of 43 dBW throughout the continental U.S.) is available at approximately $400 per transponder-hour, an estimated 8,170 channel hours would be utilized annually by these seventeen organizations. On the basis of this response, PSSC projects a demand for 12,000 channel-hours of one-way video in 1982, which represents an annual revenue of approximately $4,800,000. Although the time distribution and peak load of this requirement is unknown, PSSC estimates that three protected transponders will provide adequate service.
>
> PSSC plans to respond to this requirement in 1979 by using facilities of the Western Union and RCA satellite networks. Westar will interconnect one hundred and fifty Public Broadcasting earth stations and one hundred and ninety two National Public Radio stations. PSSC is now engaged in a study for the Corporation for Public Broadcasting to develop equitable arrangements for sharing the public broadcasting network. PSSC plans to supplement coverage available from Westar using RCA's Satcom network, which now interconnects approximately one hundred and eight cable systems.
>
> When economical service becomes available, PSSC plans to develop a continuing network which provides one-way television and two-way data to each classroom. Much of the material to be distributed will be pre-recorded, but an important element of the programs will be interaction involving use of mark-sense cards and optical card readers. Prior to the class, the students will receive study guides which contain a number of questions. The answers to these questions and others raised during the class will be answered in a multiple-choice format and relayed to the studio during the class.

The projected volume of data communications traffic is modest. Assuming that 12,000 channel-hours of programming are delivered annually, that there are an average 1,000 students per class, that the average student responds 16 times an hour, and that 30 bits of data are transferred per response, only 6 x 10 bits per year of data need be transferred while maintaining individual records. The required system throughput is so low that the economics are significantly enhanced by relying exclusively on mark-sense cards and not allowing voice feedback, which tends to be ineffective in large-audience situations anyway.

A one-way video and two-way data network could combine the best features of pre-recorded lectures, live interaction, and computer-managed instruction. Even with production costs as high as $20,000 per hour and transponder costs of $400 per hour, it would be possible to administer such a network at a profit while charging course fees of approximately six dollars per student-hour if an average of 1,000 students per class could be attracted.

The Task Force report also includes a section on education,(11) part of which is reproduced here:

The ability of a communications satellite system to relay and broadcast varying and diverse amounts of information between any number of places within its geographical area of coverage has significant implications for educational services.

Some of the points of particular interest raised were:

(i) point-point links between educational institutions originating educational television and audio programs in particular post-secondary and tertiary institutions;

(ii) one-way video/two-way audio links between educational institutions and educational centres for distance education purposes. Overseas experience suggests that two-way video is not cost effective compared with one-way video, provided each is backed up by two-way video recorders, plus the possibility of electronic reception of 'hard copy' material through slow-scan television, would add considerable flexibility in this application;

(iii) data transmissions between educational institutions for educational purposes. Centralised data with multiple access could be developed containing visual, audio and information resources;

(iv) data transmission between schools and educational authorities related principally to general administration and staffing;

(v) small-scale teleconferences and meetings for participants (teachers, administrators) separated by large distances. This capability could significantly improve 'in-service' training;

(vi) the review and exchange of curriculum material on an information basis;

(vii) research studies requiring wider sampling over large geographical areas and uniformity of presentation of stimulus materials;

(viii) the provision of educational services for disadvantaged minority groups (for example, migrants, aboriginals and other groups with special educational needs).

It is noted that the services could be provided by a terrestrial system with the exception of services to remote areas. However, it is also agreed that the Satellite offers opportunity for higher quality two-way audio transmission independent of atmospheric conditions, and that educational opportunities could cover the range from primary through to adult and continuing education.

As might be expected, cautions are raised about cost and the need for trial and experimentation.

Already much has been learned from a project initiated in 1971 with the objective of studying the benefits arising from direct conference communications between groups of common interests in widely separated centres of the Pacific. The institutions linked in this cooperative venture make use of low cost self-contained radio terminals and communication satellite relay. The project is known as Peacesat[12] involves nine countries, and communication over distances as great as that from London to Tokyo. In particular, this project has had extensive applications in education.

Quite recently the University of the South Pacific advertised a number of posts in program production and in so doing described its activities as follows:

> Since 1974 the University of the South Pacific has been operating an experimental radio communication system, linking its Extension Services Offices on the LAUCALA campus with Extension Centres and Departments of Education in other countries of the University region. The network uses Applications Technology Satellite for a total broadcasting time of 23 hours per week and now includes nine terminals all of which also participate in the Par-Pacific Educational and communication Experiments by Satellite (PEACESAT) project with an allocation of a further 21 hours per week. The system is currently being upgraded and extended with assistance from the United States Agency for International Development and NAJA, and will shortly add hardcopy and video capacity to the audio facilities already in use.

The article by Bystrom gives a great deal of information about the project and its applications. Most importantly one should note that here is a working model, in which, as I understand it, the capital costs have been borne largely by the United States but where the user costs have been borne by countries and institutions with much more modest means.

So much for the overview of communication satellite technology and the background debate about an Australian Domestic Satellite System.

## Conclusion

Arising out of a national conference on telecommunications policy and education, held at the University of Georgia, a number of recommendations were made by more than a hundred or so leaders in education and in electronic communications. Many of these recommendations were directed towards potential users suggesting that they might institute experiments and demonstrations adaptable to satellite usage. In various parts of the world, experiments have been undertaken and reported in the literature. By contrast, we appear to have been slow in Australia to act. Now, of course, an Australian satellite could be imminent and potential users will be unprepared. It is of interest to note that the national conference mentioned was reported on by Frank W. Norwood who entitled his article 'The Time for Action is Now'. The pity is that his article was published in February, 1969,[13] a decade ago. Given the liklihood of far reaching decisions about an Australian satellite system in the near future, users need to act now.

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